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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/534,946	05/11/2005	Takashi Yokoyama	94326	3657

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EXAMINER	
SONG, MATTHEW J	

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1722	

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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/534,946	YOKOYAMA ET AL.	
	Examiner	Art Unit	
	Matthew J. Song	1722	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-21 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) 1-21 is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☒ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date 5/11/05;6/6/05;6/23/05.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Claim Rejections - 35 USC § 112

1. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

2. Claim 1-9 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Claim 1 recites, "the silicon crystal is pulled up by lowering a growth condition V/G_1 to near a critical value" in line 3-4. It is unclear what the "critical value" is and how "near" a value needs to be to satisfy the claimed limitation. The same arguments apply to claims 2-9.

3. Claims 17-20 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. Claim 17 recites, "an average void defect density over the entire plane of the silicon wafer is not more than $5x10^6/cm^3$" in lines 2-3. It is unclear how a plane can have density in cm^3 because a plane is flat, thus two dimensional.

Claim Rejections - 35 USC § 102

4. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

5. Claims 1 and 4 are rejected under 35 U.S.C. 102(b) as being anticipated by Okui et al (US 6,458,204).

Okui et al discloses a method of manufacturing a silicon wafer from a silicon crystal pulled from a silicon melt comprising a boundary between the silicon crystal and the melt during the pulling of the silicon crystal being convex with respect to the melt surface (Abstract, Fig 3b, and col 4, ln 35-65). Okui et al also discloses pulling while maintaining the solid-melt interface in convex shape and temperature distribution effects the shape of the solid-melt interface (col 5, ln 65 to col 6, ln 15 and col 7, ln 1-15). Okui et al also discloses controlling the axial temperature gradient to obtain a convex shape (col 10, ln 20-40).

Okui et al does not specifically disclose the silicon crystal is pulled by lowering a growth condition V/G_l to a near critical value in a state in which the axial temperature gradient near the melting point of the crystal is increased and the solid-liquid interface is convex. However, this feature is inherent to Okui et al because Okui et al discloses forming a convex solid-liquid interface and controlling the axial temperature gradient to obtain the shape at a particular pulling rate. Therefore, the V/G_l condition claimed by applicant is inherent to Okui et al because Okui et al discloses forming a convex shape.

Referring to claim 4, Okui et al discloses magnetic field (col 9, ln 15-30).

6. Claims 10-16 are rejected under 35 U.S.C. 102(b) as being anticipated by Inagaki et al (US 2002/0144641 A1).

Inagaki et al discloses an apparatus for pulling a silicon single crystal comprising a cooler **19** provided above a silicon melt **12** for cooling the silicon crystal (Abstract and [0181]-[0184]). Inagaki et al also discloses a take up machine connected to a wire for pulling the crystal ([0292] and Fig 18), this reads on applicant's pulling mechanism.

In regards to the limitation where the silicon crystal pulling rate and an amount of cooling by the cooler are adjusted thereby lowering a growth condition to a near critical value in a state in which the axial temperature gradient near the melting point of the silicon is increased and a solid-liquid interface which is a boundary between the silicon crystal and the melt during the pulling of the silicon crystal is convex with respect to the melt and the silicon crystal is pulled up, these limitations are merely intended use. A recitation of the intended use of the claimed invention must result in a structural difference between the claimed invention and the prior art in order to patentably distinguish the claimed invention from the prior art. If the prior art structure is capable of performing the intended use, then it meets the claim. Inagaki et al discloses all of the structural limitations of the apparatus and is capable of the claimed intended use, thus meets the claimed apparatus.

Referring to claims 11-12, claim 11 only further limits claim 10 by specifying the intended use of the apparatus and claim 12 has the same structural limitations of claim 10, which is discussed previously, but differs in the intended use limitations. A recitation of the intended use of the claimed invention must result in a structural difference between the claimed invention and the prior art in order to patentably distinguish the claimed invention from the prior art. If the prior art structure is capable of performing the intended use, then it meets the claim. Inagaki et al

discloses all of the structural limitations of the apparatus and is capable of the claimed intended use, thus meets the claimed apparatus.

Referring to claims 13-14, Inagaki et al discloses a distance of 150 mm or thereabouts ([0184]).

Referring to claim 15-16, Inagaki et al does not discloses a gap of 20-100 mm. However, this is merely an intended use of the apparatus. A recitation of the intended use of the claimed invention must result in a structural difference between the claimed invention and the prior art in order to patentably distinguish the claimed invention from the prior art. If the prior art structure is capable of performing the intended use, then it meets the claim. Inagaki et al discloses all of the structural limitations of the apparatus and is capable of the claimed intended use because the cooler is movable in the vertical direction ([0185]-[0194]), thus meets the claimed apparatus.

7. Claim 17-18 are rejected under 35 U.S.C. 102(b) as being anticipated by Nakamura et al (WO 01/71069 A1), where US 6,869,478 is used as an accurate translation.

Nakamura et al teaches producing a defect free crystal where defect free means no voids defects, nor oxidation induced stacking faults or dislocation clusters ('478 col 14, ln 1-40).

Nakamura et al is silent to the size or density of void defects however no void defects inherently means zero defects with no size.

Claim Rejections - 35 USC § 103

8. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

9. Claims 2, 3 and 5-6 are rejected under 35 U.S.C. 103(a) as being unpatentable over Okui et al (US 6,458,204) as applied to claims 1 and 4 above, and further in view of Inagaki et al (US 2002/0144641 A1).

Okui et al discloses all of the limitations of claim 2, as discussed previously, except that a cooler is used to cooler the silicon crystal and the growth rate V is from 75-97% of Vmax.

In a method of pulling a silicon single crystal, note entire reference, Inagaki et al teaches as a cooler **19** is disposed within a CZ furnace and an increase in the temperature gradient of the body of the single crystal results in miniaturization of crystalline imperfections ([0184]). Inagaki et al also teaches the rate at which the silicon ingot is to be pulled can be increased and the production efficiency of the ingot can be improved ([0184]).

It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Okui et al by using the cooler taught by Inagaki et al to increase the temperature gradient and improve productivity by increasing the growth rate.

The combination of Okui et al and Inagaki et al does not teach the growth rate V is from 75-97% of Vmax. It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Okui et al and Inagaki et al by optimizing the pulling rate to obtain the claimed pulling rate by conducting routine experimentation to optimize productivity.

Referring to claim 3, the combination of Okui et al and Inagaki et al teaches using a cooler to control the temperature gradient and the temperature gradient effects the convex shape ('641 [0184] and '204 col 10, ln 15-40).

Referring to claim 5, the combination of Okui et al and Inagaki et al teaches using a cooler and controlling rotational speed of the crystal and the rotational speed of the crucible ('204 col 4, ln 35-65).

Referring to claim 6, the combination of Okui et al and Inagaki et al teaches using a cooler and producing a wafer with no OSF defects ('204 Table 1 and 2). The V/G_1 is expected to be near a critical value because a convex shape is obtained in the melt-solid interface and a wafer with no OSF defects is obtained, which is similar to the process taught by applicants.

10. Claims 7-9 and 17-18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Okui et al (US 6,458,204) in view of Inagaki et al (US 2002/0144641 A1) as applied to claims 2, 3 and 5-6 above, and further in view of Akiyama et al (EP 1137069 A1).

The combination of Okui et al and Inagaki et al teaches all of the limitations of claim 7, as discussed previously, except the claimed oxygen concentration.

In a method of making a wafer from an ingot about by the Czochralski process, note entire reference, Akiyama et al teaches it is preferable to have an oxygen concentration of 18 ppma or less and if the oxygen concentration is low, growth of the crystal defects can be further suppressed ([0090] and [0082]). The conversion of 18 ppma to atoms/cm^3 is 9x10^{17} atoms/cm^3, as evidenced by Borgini et al (US 2002/0179006 A1 in paragraph [0022]. Overlapping ranges are held to be *prima facie* obvious (MPEP 2144.05).

It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify the combination of Okui et al and Inagaki et al by using a low oxygen concentration, as taught by Akiyama et al, to suppress crystal defects.

Referring to claim 8-9, the combination of Okui et al, Inagaki et al and Akiyama et al teaches annealing at 1100-1300°C in an Ar atmosphere, this clearly suggests applicant's non-oxidative atmosphere, to eliminate defects from the surface of the wafer and producing a wafer with no OSF ('069 [0093] and '204 Table 1).

Referring to claims 17-18, the combination of Okui et al, Inagaki et al and Akiyama et al teaches no OSF ('204 Table 1) and a method of reducing the number of COPs, which are void defects, to less 100 having a size of 0.09 μm or more ('069 Fig 6) and the COP density of 0.2/cm^2 ('069 Table 1). The combination of Okui et al, Inagaki et al and Akiyama et al does not teach the average void defect density over the entire plane of a silicon wafer to not more than 5x10^6/cm^3. However, this is expected because the COP density 0.2/cm^2 is so low compared to the value of 5x10^6/ and void defects are nearly completely eliminated by the treatment and in the

plane would suggest a third dimension of nominal size. Furthermore, combination of Okui et al, Inagaki et al and Akiyama et al teaches a similar process of growing a crystal with a convex melt interface with a low amount of oxygen and heat treating in a non-oxidative atmosphere at greater than 1000°C, as applicant; therefore a similar process is expected to produce a wafer with similar properties.

11. Claims 17-18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Okui et al (US 6,458,204) in view of Akiyama et al (EP 1137069 A1).

Okui et al discloses forming a wafer with no OSF by pulling (Table 1).

Okui et al does not teach the claimed an average void density or average void size.

In a method of making a wafer from an ingot about by the Czochralski process, note entire reference, Akiyama et al teaches it is preferable to have an oxygen concentration of 18 ppma or less and if the oxygen concentration is low, growth of the crystal defects can be further suppressed ([0090] and [0082]). Akiyama et al also teaches a heat treatment to reduce the number of COP, which are void defects, having a size of 0.09 μm to less than 100 (Fig 6), this clearly suggests applicant's average void defect size is not more than 100 nm. Akiyama et al also teaches the COP density of $0.2/cm^2$ (Table 1 and [0113] and [0120]), this clearly suggests applicant's average void defect density over the entire plane of a silicon wafer to not more than $5x10^6/cm^3$ because the COP density of $0.2/cm^2$ is so low compared to the value of $5x10^6/cm^3$ and void defects are nearly completely eliminated by the treatment and "in the plane" would suggest a third dimension of nominal size.

It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Okui et al by Akiyama's process of forming a wafer with no void defects to produce a desirable defect free wafer.

12. Claims 17-20 are rejected under 35 U.S.C. 103(a) as being unpatentable over Nakamura et al (WO 01/71069 A1), where US 6,869,478 is used as an accurate English Translation, in view of Falster et al (US 2002/0121238 A1).

Nakamura et al teaches producing a defect free crystal where defect free means no voids defects, nor oxidation induced stacking faults or dislocation clusters ('478 col 14, ln 1-40).

Nakamura et al does not teach setting a carbon concentration to $1x10^{15}$ atoms/cm^3.

In a method of forming silicon single crystals, note entire reference, Falster et al teaches carbon present as an impurity in a single crystal silicon is preferably less than $5x10^{15}$ atoms/cm^3 ([0163]), overlapping ranges are held to be *prima facie* obvious (MPEP 2144.05). Falster et al also teaches carbon has the ability to catalyze into oxygen precipitate nucleation centers so it is preferred to keep carbon low ([0163]).

It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Nakamura et al by having a low carbon concentration, as taught by Falster et al, within the claimed range because carbon produces defects thus less carbon is desirable to produce fewer defects.

Referring to the limitation of producing defect free silicon by adjusting growth conditions, this is a product-by-process limitation and the patentability determination of a product-by-process claim is based on the patentability of the product and does not depend on its

method of production (MPEP 2113). The product taught by the prior art meets all of the product limitations, thus meets the claimed limitation.

Referring to claims 17-18, the combination of Nakamura et al and Falster et al teaches a defect free crystal with no void defects or OSF. The combination of Nakamura et al and Falster et al is silent to the size or density of void defects however no void defects would clearly suggests zero defects with no size.

13. Claim 21 is rejected under 35 U.S.C. 103(a) as being unpatentable over Holder et al (US 6,039,801) in view of Everts (US 5,443,034).

Holder et al discloses a pulling apparatus comprising supplying argon from near the top of the pulling apparatus through inlet **36** and exhausting gas through an exhaust system **24** located below (col 4, ln 1-35 and Fig 1). Holder et al also teaches a crucible **12**, and heat shield **40** and **42**.

Holder et al does not teach the heat shield can be raised and lowered.

In an apparatus for crystal pulling, note entire reference, Everts teaches a CZ furnace where a heat shield can be raised an lowered above a crucible (Abstract). Everts also teaches a heat shield that is compact, simple to use and would compensate for the differences in height between the raw silicon and the molten silicon bath (col 1, ln 60 to col 2, ln 5).

It would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Holder et al by using the heat shield that can be raised and lowered, as taught by Everts, to compensate for differences in height and adjust the heat shield to a desired location during manufacturing.

Referring to the limitations of requiring positioning of the heat shield where a carbon concentration inside the pulled single crystal is $3x10^{15}$ atoms/cm^3 or less and the silicon single crystal is pulled with growth conditions adjusted such that defects are eliminated from the pulled silicon single crystal, these are merely intended use limitations. A recitation of the intended use of the claimed invention must result in a structural difference between the claimed invention and the prior art in order to patentably distinguish the claimed invention from the prior art. If the prior art structure is capable of performing the intended use, then it meets the claim. The combination of Holder et al and Everts teaches all of the structural limitations of the apparatus and is capable of the claimed intended use, thus meets the claimed apparatus.

Conclusion

14. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Borgini et al (US 2002/0179006 A1) teaches a wafer may have an oxygen concentration falling anywhere within the range attainable in a CZ process, which is typically about $5x10^{17}$ to about $9x10^{17}$ atoms/cm^3 or about 10 to about 18 ppma ([0022]).

15. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Matthew J. Song whose telephone number is 571-272-1468. The examiner can normally be reached on M-F 9:00-5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Yogendra Gupta can be reached on 571-272-1316. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

Matthew J Song
Examiner
Art Unit 1722

MJS
June 8, 2007

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PRIMARY PATENT EXAMINER
A.U. 117